Nitrates, Chlorates and Trihalomethanes 
In Swimming Pool Water

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Abstract: Water from swimming pools in the Miami area was analyzed for nitrates, chlorates and trihalomethanes. The average concentrations of nitrate and chlorate found in freshwater pools were 8.6 mg/liter and 16 mg/liter respectively, with the highest concentrations being 54.9 mg/liter and 124 mg/liter, respectively. The average concentration of total trihalomethanes found in freshwater pools was 125 μg/liter (mainly chloroform) and in saline pools was 657 μg/liter (mainly bromoform); the highest concentration was 430 μg/liter (freshwater) and 1287 μg/liter (saltwater). The possible public health significance of these results is briefly discussed. (Am J Public Health 70:79-82, 1980.)

The water of swimming pools should be of the same quality as drinking water, according to White and a publication from the Center for Disease Control. The water of selected pools in the Miami, Florida area was examined for contaminants that might present a health hazard to users. No references were located to previous studies of nitrate, chlorate or trihalomethanes in swimming pool water. The National Interim Primary Drinking Water Regulations standard for nitrate nitrogen is 10 mg/liter. This is equivalent to 45 mg/liter of nitrate. A standard has not been issued for chlorate in drinking water. The proposed interim standard for total trihalomethanes in drinking water is 100 μg/liter.

TABLE 1—Nitrate as NO₃⁻ mg/liter

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>High</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline pools</td>
<td>18</td>
<td>13.5</td>
<td>2.7</td>
<td>3.2</td>
</tr>
<tr>
<td>Hotel and motel pools</td>
<td>61</td>
<td>20.6</td>
<td>7.4</td>
<td>5.0</td>
</tr>
<tr>
<td>Condominium and apartment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>house pools</td>
<td>20</td>
<td>54.9</td>
<td>16.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Municipal pools</td>
<td>20</td>
<td>18.7</td>
<td>4.5</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Methods

Water samples were collected, transported and stored according to the Environmental Protection Agency (EPA) recommendations. Nitrate was analyzed by the cadmium reduction method of Standard Methods. Initially, chlorate was measured iodometrically after distillation by the method of Williams and Meeker as modified by Jacobs. Later, chlorate analyses were by the Dionex Model 10 ion chromatography unit, deducting the nitrate contribution to the mixed peak.*

TABLE 2—Pools with High Nitrate and Chlorate

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>NO₃⁻ mg/l</th>
<th>ClO₃⁻ mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>18.7</td>
<td>72</td>
</tr>
<tr>
<td>30</td>
<td>54.9</td>
<td>41</td>
</tr>
<tr>
<td>54</td>
<td>30.8</td>
<td>70</td>
</tr>
<tr>
<td>57</td>
<td>28.8</td>
<td>93</td>
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<td>58</td>
<td>24.6</td>
<td>73</td>
</tr>
<tr>
<td>83</td>
<td>10.9</td>
<td>124</td>
</tr>
<tr>
<td>84</td>
<td>8.9</td>
<td>122</td>
</tr>
</tbody>
</table>

*Recovery experiments showed improved accuracy and precision using ion chromatography. Chloride and bromide interfered with chlorate analyses in high salinity waters. Details of this method will be published elsewhere.
Trihalomethane analyses were performed using the method of Bellar and Lichtenberg\textsuperscript{9} with a Tracor 560 gas chromatography unit fitted with an integrator and a Tracor 700 Hall electrolytic conductivity detector. A standard solution of trihalomethanes was also run daily for comparison purposes.

Results

Table 1 summarizes the nitrate found in four groups of open air pools from the greater Miami area, and Figure 1 shows the frequency distribution of concentrations. All the pools were disinfected with chlorine. Except for the saline pools, they were all filled with city municipal water, which has an average nitrate concentration of less than 0.1 mg/liter as NO\textsubscript{3}-\textsuperscript{10}. The average nitrate concentration found in 101 freshwater pools was 8.6 mg/liter. Only one freshwater pool contained less than 1 mg/liter of nitrate.

Samples\textsuperscript{11} showed that the two nitrogen atoms of urea are eventually oxidized to nitrate by the action of chlorine. This suggests urine as a possible source of nitrate. Pools in apartments or hotels catering to families with children were generally found to contain higher nitrate than those catering to adults only.

Low nitrate values were obtained for 19 of the 20 municipal pools analyzed. The 19 samples were taken within a few weeks of filling and stabilizing the pool. The one high value was from a municipal pool that had retained its water from the previous season. The water of most of the pools in the other groups was changed only after heavy contamination or for repainting.

The chlorate concentrations were determined to be quite variable. The average value was 16 mg/liter with a standard deviation of 23.8. Chlorate was not detectable in 20 pools while 12 pools contained 40 or more mg/liter. It is speculated that the pools without chloride may have been more regularly maintained within the recommended range of pH 7.2-7.8, because chlorate formation is greatly reduced under alkaline conditions. The frequency distribution of concentrations is shown in Figure 1. In several pools high nitrate was accompanied by high chlorate. Some of these results are shown in Table 2.

The concentrations of trihalomethanes found are summarized in Table 3 and their frequency distribution is shown in Figure 2. It is speculated that the values are the resultants from continuous formation and continuous surface evaporation. Continuous formation of trihalomethanes would be expected from interaction of the chlorine or hypochlorite added regularly, and organic materials that enter the pool via users, the environment and make-up water. The residual chloroform of Miami municipal water ranged from 30 to 300 \( \mu \)g/liter in a recent survey.\textsuperscript{12} Water from two unused and unchlorinated pools filled from municipal water were analyzed. They contained 1 and 4 \( \mu \)g/liter of trihalomethanes (chloroform only). Dilling, et al.\textsuperscript{13} observed rapid evaporation of chloroform from dilute solutions.

The pattern of trihalomethanes in saline pools was different from that of freshwater pools. This was expected because of bromide ions in saltwater. However, the concentrations of bromoform found were greater than expected by comparison with the chloroform concentrations of freshwater pools. Four of the 18 saline pools examined had bromoform values greater than 1 mg/liter (1000 \( \mu \)g/liter) and all except one were greater than 100 \( \mu \)g/liter. The higher concentrations found may be because bromoform is less volatile than chloroform and would be expected to evaporate less readily from the pool surface.
Discussion

The interim standards for drinking water are based on presumed ingestion of two liters daily. This obviously exceeds the amount of water likely to be ingested by pool users. Healthy adults can consume large amounts of nitrate without apparent ill effects; however, the interim standard for nitrate is reported to offer little margin of safety for some infants.

Ingestion of chlorate has also been associated with formation of methemoglobin, although very large doses of potassium chlorate (1.8 gm/kg) were needed to demonstrate the effect in dogs. Becker et al. showed that chlorate did not cause methemoglobinemia in rats but that simultaneous administration of chlorate and nitrite produced much higher levels of methemoglobin than could be produced by nitrite alone (chlorate is converted to nitrite by the human intestinal flora).

In recent years there has been a substantial increase in the number of infants, ages three months and upward, who are immersed regularly in swimming pool water in “Moms and Tots” and similar training programs. Although nothing has been published to link these programs with any hazard from nitrate or chlorate ingestion or to oral or percutaneous absorption of trihalomethanes, we believe that further investigation of the possible hazards of swimming pool water to young infants is in order. In addition to repeating studies similar to ours in other areas, the possible synergism between chlorate and nitrate in producing methemoglobinemia, and the absorption of trihalomethanes through the skin deserve to be studied. Estimates of the amount of water infants and young children ingest when using swimming pools and the extent of pool contamination by urine would also be of value.

REFERENCES

Use of a Monthly Health Review to Ascertain Illness and Injuries

C. DAVID JENKINS, PhD, BERNARD E. KREGER, MD, ROBERT M. ROSE, MD, AND MICHAEL HURST, EdD

Abstract: A Monthly Health Review was developed to monitor symptoms, illnesses and injuries among Air Traffic Controllers. Return rate of the mailed check-list exceeded 90 per cent. Diagnoses were generated from symptom clusters by computer algorithms. Telephone interview by physicians, laboratory analyses for serum pepsinogen I, and analyses of relations between symptom clusters and degree of disability all served to support the validity of the methodology. Such a system can provide inexpensive surveillance of morbidity in suitable populations. (Am J Public Health 70:82-84, 1980.)

Maintaining good health is a major concern in industrial populations, especially where known hazards exist. We have recently developed and evaluated a system for monthly self-report of signs and symptoms of illness as a means of monitoring health status between periodic medical examinations. The present report describes the data collection technique and presents evidence for its validity.

Materials and Method

The Boston University Medical Center—Air Traffic Controller Health Change Study began in January 1974 to measure health status among 416 air traffic controllers in New York and New England. These men, 25 to 49 years of age at entry into the study, made five visits to the Medical Center during three years for comprehensive medical and psychologic examinations.

At the end of each month, each participant received a copy of a Monthly Health Review* by mail. He was asked to think back over the calendar month just concluding, recalling whether he had experienced an "illness episode," and to check from a list of 30 symptoms those which had occurred infrequently, by themselves, and not as part of a larger picture of disease. These were checked separately as "isolated events." Finally, those symptoms which were not part of illness episodes, but which were present at least half the days of the month, were to be indicated in the "continuing problems" column. These concepts were operationally defined in simple terms in the introduction to each copy of the MHR.

A separate section asked about injuries. The respondent was asked to indicate, for each illness episode or injury as well as for the totals of isolated events and continuing problems, how many days he felt below par and how many days he cut down on his usual activities, including time lost from work, and to note whether medical care was obtained for each condition. Space was provided to indicate hospitalizations and events not covered in the check list.

All MHRs for January and February 1975 were screened for the presence of respiratory symptoms checked as part of

*Available on request to author